

## **Chapter 4. ENVIRONMENTAL IMPACT ANALYSIS**

This section discusses the impacts or effects of the proposed project on the existing environment described in Chapter 3. The proposed project and most alternatives will permit a continuation of the regulated commercial harvest of Pacific herring in California. Existing regulations permit the commercial harvest of herring in five geographical areas: San Francisco Bay, Tomales Bay, Humboldt Bay, the Crescent City area, and the open ocean (Monterey Bay). A preliminary assessment was performed of the environmental sensitivity in each area to existing commercial harvest levels to provide focus for the impact analysis (Table 4.1).

### **4.1 Preliminary Assessment**

Thirteen general environmental categories were selected for consideration in the preliminary assessment (Table 4.1). Three categories (land use, archaeology, and growth inducement) were considered to have no environmental sensitivity to commercial herring fishery activity in any geographical area. The basis for this assessment and the elimination from further consideration is provided below.

#### **Land Use:**

Dockside berthing and product processing facilities are the principal land-based facilities supporting commercial herring fishery operations. The facilities that handle Pacific herring also handle a wide variety of other commercial fishing products. The dynamic nature of commercial fishing activities has lead to considerable flexibility in the ability of the land-based support facilities to switch among a variety of vessels and products. These facilities are adequate to handle the quantity of herring likely to be available from existing or foreseeable stock levels. The proposed project and alternatives should not lead to a change in land use or a change in existing land use that supports a broad spectrum of commercial fishing operations.

#### **Growth Inducement:**

Approval of the proposed project or alternatives will not induce growth in the fishing industry. The herring roe and herring eggs-on-kelp (ROK) fisheries in the State are limited entry fisheries. The California Fish and Game Commission established a ceiling on the number of permits to be allowed in the herring roe fisheries in the 1980-81 season. No increase in the number of herring roe permits has occurred since 1986 [Sec 3.2.4.2], when the last five were issued, precluding any further roe fishery growth. The number of permits available in the ROK fishery has increased; but, not the total number of permittees in both fisheries. Available ROK permits are issued only to herring roe permittees in lieu of fishing for herring roe. The open-ocean herring fishery is the only herring fishery with no limit on the availability of permits. Although no quota exists, market conditions have historically limited this fishery. In 1989, less than one percent (0.13%) of the statewide herring landings were made by this fishery. The proposed project or alternatives are not expected to result in noticeable growth in the project areas.

#### **Archaeology:**

Commercial herring fishing operations are, by their nature, water based activities. Submerged historic archaeological sites exist in the San Francisco Bay and Tomales Bay areas where commercial herring activities occur (MMS 1990). However, the soft-bottom sediments in those areas supporting herring roe fisheries and the relatively light weight of most commercial gear (anchors) preclude extensive damage to existing submerged historic or prehistoric remains (Alex Watt, MMS archaeologist, pers comm).

Traffic circulation including parking would potentially be impacted to varying degrees for the

entire fishing season lasting 109 days (including non-fishing days).

**Mitigation:** Traffic circulation impacts are expected to be localized, short-term, and less than significant. Mitigation for impacts to traffic circulation is provided by regulations which: 1) prohibit fishing in selected high-traffic areas and on weekends, 2) require the permittee and permit vessel to be within one nautical mile of set fishing gear, 3) limit the amount of gill net gear to one net (shackle) per permittee, and 4) require eggs-on-kelp lines be suspended under suitable permanent structures so as not to hinder navigation, and eggs-on-kelp rafts or lines must be tied to a permanent structure (e.g. pier, dock) when placed in Belvedere Cove or Richardson Bay.

#### 4.2.2 Water Quality

The potential for adverse impacts to water quality was considered to exist to some degree in all geographical areas supporting commercial herring fishing.

The principal potential adverse impacts to water quality are associated with the discharge of a slurry used to pump herring from the hold of the vessel to the dock, and the suspension of sediments from the bottom due to fishing activity. Saltwater is added to the herring in the hold of the boat to create a slurry just prior to off-loading. Decanted slurry would contain organic wastes including fish scales, eggs, and milt. The water quality variables potentially affected by the pumping operation are turbidity, dissolved oxygen levels, temperature, and nutrient concentration. Site-specific data on water quality characteristics at the herring pumping stations in the San Francisco Bay area are not available. Off-loading herring frequently occurs during ebb and flood tides when water movement limits fishing opportunities. With rapid water movement, changes in water quality characteristics would tend to be localized and of short duration.

Concentrations of suspended solids in the water column are likely to increase temporarily due to propeller wash in shallow water or contact of fishing gear with the bottom. The increases in turbidity would tend to be of short duration. However, the fine-grained sediment fractions (clay and silt) have a high affinity for several contaminants, such as trace metals and organics. This

sediment fraction tends to remain in the water column longer than sand because of a lower settling velocity.

No significant long-term impacts are expected as a result of fishing-induced turbidity. However, some short-term impacts could occur. Bioassays using Bay sediments in suspension resulted in mortalities for some representative aquatic organisms (mysid shrimp) at all concentrations of particulates (U.S. Navy 1990). Sediment on spawning substrate may also inhibit spawning by herring (Stacy and Hourston 1982) and affect embryo survival (Lough et al. 1985).

Concern exists over the presence of radiation and other contaminants in the sediments at the Treasure Island Naval Station Hunters Point Annex (Barbara Smith, Regional Water Quality Control Board, pers. comm., Jeff Lewis, Department of the Navy, pers. comm.). Herring utilize pier pilings, sea walls, and rocky shoreline at Hunters Point for spawning. It is not known what effect, if any, contaminated sediments have on embryo and larval survival. Illegal fishing activity in the Hunters Point area would disturb sediments and possibly create an increased yet short-term exposure hazard to humans as well as the biota (Agency for Toxic Substances and Disease Registry, 1994). However, a restricted zone prohibits vessels from entering the area off of Hunters Point.

In the eggs-on-kelp fishery, kelp with no eggs or unacceptably few eggs attached, or unmarketable kelp stipes are returned to the water so that the eggs will have a greater probability of survival. The remaining decomposing kelp may have adverse but short-term effects on water quality.

**Mitigation:** Because the effects of increased turbidity, light attenuation and reduction in dissolved oxygen would be temporary and localized, and because a restricted area at Hunters Point prohibits any vessel traffic, no mitigation measures are proposed for impacts on water quality.

#### 4.2.3 Air Quality

All areas supporting commercial herring operations were considered to have some level of sensitivity to impacts to air quality. However, the highly urbanized San Francisco Bay area was deemed to have the greatest sensitivity and provided the focus for the impact assessment.

Air quality is affected by emissions generated from the operation of gas and diesel engines in commercial fishing vessels, from the operation of gas and diesel engines in support vehicles, and from the operation of gas powered pumps used in off-loading operations.

Pollutant emission rates were estimated using the following assumptions regarding fishing activities and equipment.

vessels:	172 maximum using gill nets or harvesting eggs on kelp on any given day during peak fishing periods
	24 maximum assessing fish distribution or fishing during off-peak fishing periods
fuel usage:	11,008 gal/day during peak fishing periods (172 vessels x 8 gal/hr x 8 hr/day)
	1,536 gal/day during off-peak fishing periods (same fuel and activity rates)
emission factors:	adequately represented by off-highway mobile source information for vessels with inboard engines in coastal environments (source EPA, AP42, 1985)

Pollutant emission factors used in the calculations were based on use of diesel fuel and are as follows:

Carbon Monoxide (CO)	=110 lb/1000 gal fuel
Hydrocarbons (HC)	= 50 lb/1000 gal fuel
Nitrogen Oxides (No <sub>x</sub> )	=270 lb/1000 gal fuel
Sulfur Oxides (So <sub>x</sub> )	=27 lb/1000 gal fuel

The pollutant emissions released when vessels are underway are influenced by a variety of factors including power source, engine size, fuel used, operating speed, and load. The emission

factors and assumptions used can only provide a rough approximation of daily emission rates. The estimated maximum daily emission rates for commercial fishing vessel operation during a season are at or well below one percent of San Francisco County daily emission rates, except for nitrogen oxide and sulfur oxide levels during peak fishing periods (3.46%, 1.49% respectively) (Table 4.2) (Bay Area Air Quality Management District 1993). An increase in pollutant emissions of one percent or less would have no significant short-term effect on the air quality in the Bay Area.

The number of support vehicles operating during the fishing season is unknown; however, to assess impacts from vehicle emissions, it is assumed that one support vehicle exists for each fishing vessel.

vehicles:	172 light duty trucks (sec 4.2.1)
usage:	local (20 mi/day)
emission factors:	adequately represented by emission rates generated at 75° F while traveling at 19.6 mph with 50% cold and 50% stabilized starts (source EPA, AP42, 1985)

Pollutant emission factors used in the calculations were as follows:

Carbon Monoxide (CO)	= 45.62 g/mi
Hydrocarbons (HC)	= 4.77 g/mi
Nitrogen Oxides (NO <sub>x</sub> )	= 3.94 g/mi
Particulates	= 0.16 g/mi

The pollutant emissions released by support vehicles are well below one percent of the San Francisco County daily emission rates (Table 4.3). An increase in pollutant emissions of less

than one tenth of one percent would have no significant short-term effect on the air quality in the Bay Area.

No long-term adverse impacts on Bay Area air quality are anticipated since no increased vessel activity is expected as a result of adopting the proposed regulations or alternatives.

**Mitigation:** Because no short-term or long-term adverse impacts on air quality are expected as a result of commercial herring fishing activity in San Francisco Bay, no air quality mitigation is proposed

Table 4.2. Daily Emission Rates From Commercial Herring Fishing Vessels(Tons/Day) in Comparison With San Francisco County Emission Rates (1990)					
Pollutant	S.F. Rate	Fishing Rate	% of S.F. Rate	Searching Rate	% of S.F. Rate
Carbon Monoxide	235.0	0.065	.26	0.084	.04
Sulfur Dioxide	59.0	0.275	.47	0.038	.06
Nitrogen Oxides	43.0	1.490	3.46	0.027	.48
Sulfur Oxides	10.0	0.149	1.49	0.021	.21
Table 4.3. Daily Emission Rates From Commercial Herring Fishing Support Vehicles (Tons/Day) in Comparison With San Francisco County Emission Rates					
Pollutant	Vehicle Emission Rate		S.F. Rate	% of S.F. Rate	
Carbon Monoxide	.1730		235.0	.074	
Hydrocarbons	.0181		59.0	.031	
Nitrogen Oxides	.0149		43.0	.035	
Particulates	.0006		39.0	.002	

#### 4.2.4 Housing and Utilities

The San Francisco Bay area supports the only fishery that is conducted by a large proportion of

individuals from outside normal commute distances. Most permittees in other fisheries live in the immediate geographical area and the potential for impacts to housing and utilities is considered to be inconsequential.

Permittees, crew members, and fish buyers from outside the San Francisco Bay Area have to use temporary housing during the fishing season in San Francisco Bay. Eighty-two percent (342) of the 1990-91 season permittees fishing gill nets or round haul nets provided addresses outside of Bay area counties (assumed commute distance). Each gill net permittee has two or three crew members. Dividing the gill net permittees into platoons with different fishing seasons

reduces the housing need. The largest number likely to need housing during the 1990-91 season, assuming 82% of the maximum crew need housing, is 650 individuals. However, the proportion of crew members from the local area is unknown and could be higher than assumed. In addition, many permittees and crew members live aboard their vessels during the herring season. No significant ecological effects or impacts are expected as a result of the increased need for housing or utilities.

**Mitigation:** No mitigation is proposed for impacts to housing and utilities because they are expected to be localized, short-term, and less than significant.

#### 4.2.5 Geological

Potential geological impacts from commercial herring fishing activities are most likely in those geographical areas that support the largest fisheries. Analysis focused on potential geological impacts in San Francisco Bay.

Potential adverse impacts include scouring of soft-bottom sediments by propeller wash in shallow water areas and disruption of sediments while setting and pulling fishing gear (nets or anchors dragging along the bottom). However, the fine-grained muds found in most fishing



areas within the Bay are constantly being resuspended, transported and redeposited by water movement. The dynamic nature of fine-grained sediment deposition suggests that no significant short-term or long-term impacts to the geology of the Bay bottom are likely.

Concentrations of suspended solids in the water column are likely to increase temporarily due to propeller wash in shallow water or contact of fishing gear with the bottom. The increases in turbidity would tend to be of short duration. However, the fine-grained sediment fractions (clay and silt) have a high affinity for several contaminants, such as trace metals and organics. This sediment fraction tends to remain in the water column longer than sand because of a lower settling velocity.

No significant long-term impacts are expected as a result of fishing induced turbidity. However, some short-term impacts could occur. Bioassays using bay sediments in suspension resulted in mortalities for some representative aquatic organisms (mysid shrimp) at all concentrations of particulates (U.S. Navy 1990). Sediment on spawning substrate may also inhibit spawning by herring (Stacy and Hourston 1982) and affect embryo survival (Lough et al. 1985).

**Mitigation:** No mitigation is proposed for geological impacts. The impacts on marine organisms suggested by the suspended phase particulates tests are short-term.

#### 4.2.6 Biological

Potential environmental impacts to biological resources exist in all geographical areas that support commercial herring fisheries. This is because Pacific herring populations can fluctuate widely and play an important role in many marine food webs. The potential impacts may be divided into two categories: (1) direct harvest impacts and (2) trophic level (food web) impacts.

Both short-term and long-term potential adverse impacts exist within each broad category.

##### 4.2.6.1 Direct Harvest Impacts

Potential short-term direct harvest impacts include: effects on individual herring, effects on

associated species incidentally taken, and effects on benthic organisms. Individual herring suffer death by suffocation during commercial harvest activities. Whether or not inflicting this pain for commercial profit, is ethically acceptable, is a topic of public debate not easily resolved. It is certainly not acceptable to some groups in our society (People for the Ethical Treatment of Animals (PETA) Factsheet). However, the fact that pain is experienced or individual herring die in the course of commercial fishing operations has no significant environmental impacts beyond the loss of individuals from a population.

A number of associated species are accidentally taken during commercial herring fishing operations. Species observed in gill nets include: jacksmelt, sardine, perch, soupfin shark, American shad, white croaker, and unidentified crab. However, the potential exists for any fish and for many invertebrates in the area to be taken. The species most likely to be taken are relatively small in size and more vulnerable to the mesh size used in herring gill nets.

No data exist on the relative rates of incidental take of other fish species in commercial gill nets set to catch herring. However, research gill nets with panels having mesh sizes that overlap the commercially legal mesh size have been used extensively by CDFG in San Francisco Bay.

Although not identical to commercial gill nets, they were set to catch herring and provide some indication of the relative rate of the incidental take of other fish species (Table 4.4). Also, the nets were set throughout the herring season and were fished both during the day and night.

Although the influence of overlapping mesh sizes cannot be factored out, less than one-half of one percent of the total catch of herring were incidentally caught species. The species taken in addition to herring included: brown smoothhound, spiny dogfish, English sole, Pacific sanddab, staghorn sculpin, smelt, shiner perch, and jack mackerel. No significant short-term or long-term ecological effects are expected as a result of this rate of take.

Table 4.4. Rate of Take (Proportion of Total Take) of Incidentally Caught Fish in Research Gill Nets Set to Catch Herring.				
Season	Hours Fished	Herring Caught	Incidental Catch	Incidental Rate
1982-83	154.0	4393	7	.0016
1983-84	78.6	1636	8	.0049
1988-89	18.3	440	1	.0023

Gill nets are lost in the course of herring fishing activities. Not all are recovered (ghost nets) and those nets, to varying degrees, continue to capture fish and invertebrates. Currents, tides, and bottom debris in San Francisco Bay can tangle (ball up) lost nets. This is particularly true when floats and anchors are removed and only net mesh attached to the lead or float line remains. No data are available to determine the number of nets lost, the proportion of net that continues to fish, nor the quantity of organisms entrapped in the lost nets. However, some measure of the number of nets recovered is available. During the 1989-90 season, the crew of the CDFG Patrol Vessel Chinook recovered or arranged for recovery of 22 ghost nets. Patrol activity included echosounder surveys in heavily fished areas immediately after fishing effort ceased. Five of the recovered nets had marketable quantities (over one thousand pounds) of fresh herring; four were balled up with some herring; two had sturgeon entangled that were released alive. The remaining nets did not have large quantities of any fish species. The number of lost or ghost nets recovered each season is declining, only three such nets were found following herring fishing activity in the 1991-92 season. Moreover, the amount of gill net gear was reduced by 50 percent beginning with the 1993-94 season, when regulations were enacted limiting each permittee to one net (shackle). The potential impacts to aquatic resources from "ghost" net fishing can be inferred from these data. No significant long-term adverse impacts to aquatic resources are

expected.

Field observations by Department staff have confirmed the absence of incidentally-taken species by the eggs-on-kelp fishery. The open pound method used by this fishery consists of suspending giant kelp, *Macrocystis* sp. from an unenclosed floating raft or line in a likely spawning area, with the expectation that free-swimming herring will spawn on the kelp fronds. Thus, unlike an encircling or entangling net, this form of egg harvest is not likely to incidentally take fish or other marine organisms.

**Mitigation:** The potential adverse impact on incidentally- taken species has been mitigated by a regulation prohibiting possession of sturgeon, halibut, salmon, and striped bass on any vessel involved in herring fishing. Because lost nets can continue to fish for extended periods of time, short-term impacts could be alleviated by continuing or intensifying patrol activity directed toward location and removal of lost nets. Mitigation for unrecovered gill nets in San Francisco Bay is provided by the restriction to one shackle of gill net, and the requirement that the net be tended.

Anchors and nets both have the potential for disturbing the bottom and impacting bottom-dwelling (benthic) animal species as well as subtidal vegetation. However, the soft-bottom benthic communities where herring roe and eggs-on-kelp fisheries occur are dynamic, having to adapt to wide salinity fluctuations and varying sediment stability (Herrgesell et al. 1983). The potential for individual organisms or vegetation to be lost is recognized; however, no data exist to quantify that loss. Localized areas, where net fishing is intense, would suffer the greatest short-term adverse effects. Additionally, herring egg deposits on substrates in shallow, soft-bottom areas could be affected by siltation from fishing-vessel propeller wash. However, the fine grained muds found in most fishing areas within the Bay are constantly being re-suspended, transported and redeposited by water movement. No significant long-term ecological effects are expected as a result of gear disturbance.

**Mitigation:** The short-term impacts of anchors and nets on benthic communities could be mitigated, if necessary, by use of drift gill nets; however, the use of drift gill nets has not proven effective in San Francisco Bay. Drift gill nets have been historically employed in the Humboldt Bay fishery. The potential impacts of eggs-on-kelp fishery anchors and vessels on shallow, soft-bottom communities and associated herring egg deposits is mitigated by the requirement that eggs-on-kelp rafts or lines be secured to permanent structures in Belvedere Cove and Richardson Bay.

Potential long-term direct harvest impacts are primarily stock related. The following discussion suggests that adverse impacts to herring stocks could exist as a result of commercial herring fishing activity. Herring stocks are noted for their instability under fishing pressure, frequently leading to stock collapse (Appendix 3). The potential for a stock to collapse in California is greatest in those stocks where stock evaluation is minimal. Evaluation of the status of stocks in California relies on a variety of independent stock assessment techniques such as spawn escape-ment surveys, hydroacoustic survey, and cohort analysis [Sec 3.2.2]. However, those techniques have been applied primarily to the largest stocks (San Francisco Bay and, to a lesser extent, to Tomales Bay and Humboldt Bay) [Sec 3.2.2]. Although Humboldt Bay and Crescent City spawning areas and the Monterey Bay open-ocean area continue to support small fisheries, ongoing evaluations of stock status and corresponding management adjustments to fishing pressure are not made.

The potential also exists for a stock to collapse in the intensively managed fisheries. The likelihood of this occurring is greatly reduced by the use of a conservative management strategy and a variety of independent stock assessment techniques. As discussed in Section 3.2.2 and Section 3.2.4, management objectives have been conservatively set by the Department based on an evaluation of results of mathematically modeling a variety of harvest strategies. The strategy selected sets a constant proportion harvest quota (<20 %) based on the prior season's spawning biomass. Only during the 1977-78, 1983-84 and 1992-93 seasons have quotas allowed a higher

than desired catch in San Francisco Bay using this strategy (Figure 3.16). During the 1973-74, 1977-78 and 1992-93 seasons, management objectives were not met for the San Francisco Bay stock when catches exceeded 20% of spawning biomass. Catches in the San Francisco Bay herring roe fishery averaged slightly over 15% of spawning biomass for all other seasons combined. Catches in Tomales Bay have averaged 12.6% of spawning biomass over 19 seasons. Tomales Bay catches have exceeded the 20% recommended harvest rate during the 1987-88, 1988-89 and 1995-96 seasons.

Even with no commercial harvest, herring stocks can decline or fluctuate due to environmental influences [Sec 3.2.1]. Therefore, with a fishery, management must be prudently responsive in adjusting fishing pressure. The Commission has demonstrated its ability to respond to stock status concerns by reducing the San Francisco Bay harvest rate following the 1983-84 El Niño, and in 1992-93, 1993-94, and 1994-95 due to biomass declines, and by setting provisional quotas for the Tomales Bay fishery.

The degree to which California's herring spawning stocks mingle in the open ocean is unknown, and is a point of management concern, particularly for the Tomales Bay and San Francisco Bay areas. However, Moser and Hsieh (1992) suggest that Tomales Bay and San Francisco Bay herring are separate stocks that do not mingle in the open ocean. Differences in age-specific size between Tomales Bay and San Francisco Bay spawning populations also suggest separate stocks [3.2.1.7]. However, if they originate from the same stock, San Francisco Bay biomass could remain high in the short-term through immigration from Tomales Bay despite actual declining population size. Data from Tomales Bay stocks do suggest that erratic biomass levels are attributable to emigration (leaving).

In addition to known fishing mortality through the harvest of herring, additional fish are lost as a

result of fishing practices. The potential exists for adverse environmental impacts as a result of this unaccounted for fishing mortality. Unaccounted for harvest includes: fish dropping from gill nets, fish caught by lost gill nets, and illegal take beyond established quota levels. No direct data are available to quantify the additional amount of fishing mortality from these sources individually or collectively in California fisheries. However, "drop-out" from herring gill nets was considered to be an insignificant cause of mortality in British Columbia fisheries (Hay et al. 1982).

From a population dynamics perspective, all sources of mortality associated with fishing beyond those fish landed can be combined with natural mortality. Whether the fish are lost and unaccounted for as a result of fishing practices or lost through natural causes (such as predation), they are not available as part of the next season's spawning biomass, and quotas are adjusted accordingly. If the level of unaccounted for fishing mortality does not increase natural mortality beyond the assumed level of  $M=0.4$  [Sec 3.2.4], no significant long-term adverse environmental impacts to the stock are expected. However, if unaccounted for fishing losses are chronic and severe, and increase natural mortality above the assumed level of  $M=0.4$ , the possibility of a gradual population decline exists. Biomass data [Sec 3.2.2] for the San Francisco Bay stock shows marked fluctuations, which have been linked to environmental conditions rather than unaccounted for fishing mortality. However, even if the unaccounted for losses are sporadic, they can have potential environmental impacts at the trophic level (discussed below).

**Mitigation:** Mitigation of the potential long-term impacts on the herring resource from stock collapse is provided by the implementation of current assessment techniques and management strategies. Annual stock assessments should herald any decline before the potential for a significant impact can be realized. These annual assessments are made for the Tomales Bay and San Francisco Bay stocks; the smaller Humboldt Bay and Crescent City stocks are not assessed annually. If stock collapse occurs, regardless of causal factors, fishery closures will be implemented to provide further protection.

Mitigation is also provided by limiting harvest quotas to no more than 20% of the previous season's spawning biomass estimate.

Mitigation of unaccounted for fishing losses is provided by an intensive enforcement effort as part of herring management. Establishing the closure of deep water areas in south San Francisco bay to gill net fishing serves to mitigate the impacts of unaccounted for losses. Mitigation is also provided by the counting of all trim, except stipes, towards eggs-on-kelp harvest quotas, and the conditional allowance for eggs-on-kelp harvest on weekends.

#### 4.2.6.2 Trophic Level Impacts

Herring occupy an intermediate position in a number of marine food webs [Sec 3.2.1.8 - 3.2.1.10], transferring energy from primary producers (phytoplankton) to predators at higher feeding strata (fish, birds, marine mammals). The harvest of herring from the marine system has the potential to impact a wide variety of species connected through these food web relationships.

Impacts include: a reduced availability of spawned eggs for consumption by invertebrates, fishes, and birds, and a reduction in adult herring for consumption by fishes, birds, and marine mammals. However, the extent of these impacts is difficult to assess because the complex and dynamic nature of marine food webs makes it particularly difficult to determine the extent that predator populations rely upon herring in their diet. For example, spawned herring eggs are available for relatively short periods during the winter months and restricted to a relatively few estuarine environments; thus, the degree of impact varies with geography and season.

A number of other factors influence the relative importance of herring as prey. The relative abundance of predators, their proximity to prey, predator food preferences, and competitive interactions between predator as well as prey species are examples. At higher trophic levels, spatial and temporal scales increase, with top predators feeding upon a wide choice of food species over longer periods of time and larger geographical areas. The complexity of the marine



food web provides for some stability in the system.

Predator food habit studies provide insight into the relative use of herring, food preferences, and prey availability. Predator population status assessments can further highlight areas of potential concern, particularly if herring have been identified as important prey and food availability has been identified as a factor limiting population growth. This type of information is needed to determine the potential impacts of commercial harvest of herring on predator populations.

**Marine mammals:** The possible effects of commercial fisheries on marine mammal populations have given rise to much discussion. A major international workshop that examined this question was unable to find a case in which a fish-eating marine mammal population had been adversely affected by a fishery (Beverton 1985). California stocks of Elephant seal, California sea lion, and harbor seal populations have all increased in recent years (Boveng 1988a and 1988b). However, the Steller sea lion population is decreasing and prey availability may be a factor limiting population growth.

Individual marine mammals may be affected to the extent that reduced local availability of herring could affect search effort, prey selection, or capture effectiveness. The occurrence of herring in the diet of some marine mammal species along the California coast suggests limited short-term impacts to individuals. Herring have been identified as prey for elephant seals in California (9<sup>th</sup> ranked prey in relative importance) (Morejohn et al. 1978), for harbor seals (6<sup>th</sup> rank)(Suryan and Raum-Suryan 1990), and for harbor porpoise (6<sup>th</sup> rank)(Dorfman 1990). Both harbor seals and California sea lions have also been observed feeding on herring in gill nets and round haul nets in San Francisco Bay (Miller et al. 1983). Herring have not been identified as prey for the northern fur seal, California sea lion, Steller sea lion, Pacific striped dolphin, Dall's porpoise, Pacific common dolphin, Risso's dolphin, and dwarf sperm whale sampled in

California (Jones 1981, Antonelis et al. 1984, Morejohn et al. 1978). However, several of these species are recognized herring predators in more northern latitudes (Alaskan fur seal, Steller sea lion, Dall's porpoise). The relative consumption of herring also appears to increase with latitude for some marine mammals in California (Harvey 1987).

**Mitigation** Mitigation in recognition of the importance of herring as a forage item is provided by setting conservative exploitation rates [Sec. 3.2.4]. Further mitigation, if necessary, can be achieved by selection of Alternative 1. No additional mitigation is proposed for impacts to marine mammal populations because they are expected to be localized, short-term and less than significant.

**Birds:** Many marine birds feed upon spawned herring eggs, and juvenile and adult herring within shallow embayments during the spawning season, and upon adult herring in nearshore waters during the remaining seasons [Sec 3.2.1.8.1]. The potential short-term and long-term impacts of commercial harvest of herring to bird populations can be determined by assessing the status of bird populations and the importance of herring to those populations.

A classic example linking declines of seabird predators to oceanic conditions and the collapse of a fish stock is the Peruvian anchoveta fishery. Heavy fishing pressure over several years, in combination with El Nino conditions, lead to the demise of the fishery in 1972. Three seabird species (a cormorant, a gannet, and a pelican) which fed almost exclusively on anchoveta, declined dramatically beginning in the mid-1960s and have not yet recovered (Glantz and Thompson 1981). Variation in the abundance of fish prey species, including herring, is an important factor influencing breeding season and success, breeding places, and movements of seabirds in northern or boreal latitudes (Ashmole 1971, Furness and Ainley 1984, Pearson 1968, Perrins, Lebreton, and Hirons 1991).

In California, the availability of important food fish such as anchovy and shortbelly rockfish can be an important factor affecting the status of seabird populations (Ainley and Hunt 1991).

Competition appears to exist among seabirds, marine mammals, and fisheries for use of fish resources (Furness and Ainley 1984, Ainley et al. 1994). Although seabirds may target certain prey species for specific energetic requirements, in general they are opportunistic feeders. They are able to switch to alternative prey species as they become available, often on a seasonal basis (Ainley and Boekelheide 1990).

Herring have been reported as prey during the non-breeding season for diving birds such as Common Murre, Rhinoceros Auklet, and Pelagic and Brandt's Cormorants in central California waters (Morejohn et al. 1978, Ainley et al. 1994). Herring have also been identified as an important winter and spring prey species for the Common Murre along the Marin county coastline (D. Ainley, PRBO, pers comm). Ainley et al. (1994) reported declines in Brandt's and Pelagic Cormorants and Common Murre, and increases in Rhinoceros Auklet in central and northern California waters. They attributed the cormorant and murre declines to reduced food resources during the non-breeding season. They hypothesized that the probable causes for the reduction in food resources were commercial fishing for herring and market squid, warmer oceanic conditions, and increased marine mammal populations.

Commercial herring fishing reduces the size of the spawning population by 10 to 15% each year.

Assuming a sex ratio of 50% males:females, approximately 5.0 to 7.5% of females in the spawning population do not contribute to spawn depositions upon which various marine birds feed. The effect of that removal on bird predators is not known but is likely to be less than significant. Direct feeding by birds on herring roe has only been reported in the ornithological literature as a limited, or incidental, late-winter activity (Grass 1973, Norton et al. 1990).

A removal of 10 to 15% of spawning biomass by commercial fishing may increase search effort, limit capture success, or cause a switch in prey by marine bird predators.

**Mitigation** Mitigation in recognition of the importance of herring as a forage item for birds is provided by setting conservative exploitation rates [Sec. 3.2.4]. Further mitigation, if necessary, can be achieved by selection of Alternative 1. No additional mitigation is proposed for impacts to bird populations because they are expected to be localized, short-term and less than significant.

**Fish:** The potential effects of commercial herring fisheries on predator fish growth and survival has been a long-standing question. A large number of potential fish predators have been identified [Sec 3.2.1.8.1]; however, only limited information is available to assess the potential fisheries-related impacts on these predator populations. Of 14 fish species' food habits assessed in the Monterey Bay area, four used herring as prey (Morejohn et al. 1978). Those potential predators with herring remains in their stomach included: king salmon, silver salmon, Pacific hake, and blue shark. The importance of herring (rank), based on frequency of occurrence and volume were 9<sup>th</sup>, 6<sup>th</sup>, 5<sup>th</sup>, and 16<sup>th</sup>, respectively. Those potential predators without herring remains in their stomach included: sablefish, halibut, petrale sole, lingcod, curlfin turbot, sanddab, chilipepper, white croaker, and midshipman. Herring ranked 4<sup>th</sup> in importance for king salmon in the vicinity of San Francisco Bay (Merkel 1957). Herring eggs have been identified as seasonally important to adult white sturgeon in portions of San Francisco Bay, comprising as much as 20 percent of their diet in early winter and 80 percent in late winter (McKechnie and Fenner 1971).

The white sturgeon and the Sacramento River winter-run king salmon populations in the San Francisco Bay area have declined in recent years. The sturgeon population decline appears to be associated with declines in fresh-water outflows in the Bay-Delta area (Kohlhorst et al. 1991). The winter-run king salmon population is listed as endangered under state regulation and threatened under federal regulation. The decline of this run is attributed to altered water temperatures, inadequate instream flows, poor upstream and downstream passage and reduced spawning area

and parent escapement (PMFC 1990). Neither population is considered to be food limited. Several studies have focussed on assessing herring-salmon interactions. A British Columbia study provided a range of values (% by weight) for herring in identifiable stomach contents of king and silver salmon (33-46% and 13-34%, respectively) (Pritchard and Tester 1944). The authors noted that species composition and dominance varied greatly between monthly periods and between sampling areas. However, they could not assess the effect of herring supply on salmon. A Canadian study addressing the same general question could find no relationship between the abundance of each species of salmon and the abundance of herring during a ten-year study period (Healey 1976). Herring are a major diet item of resident king salmon near Puget Sound, Washington, comprising 61% of prey biomass. Herring were most important during winter and spring (Fresh 1983). Fresh (1983) suggests that herring are not a required food item since salmon are opportunistic feeders; but, herring do contribute to a food rich environment that is attractive to salmon. Herring have been identified as important food items in a number of other king salmon food habit studies based on fish collected in waters north of California (Heg and Van Hyning 1951, Silliman 1941, Chapman 1936).

Merkel (1957) and Morejohn et al. (1978) provide the only accounts found of king salmon food habits in California waters. Pacific herring comprised approximately 13%, by volume (4<sup>th</sup> rank), of the food of king salmon in the vicinity of San Francisco. However, both studies noted marked seasonal changes in the composition of prey found in stomachs, with herring being most prevalent during the winter and spring. Merkel (1957) also noted that king salmon taken within San Francisco Bay had essentially ceased feeding.

Reduction in availability of herring through commercial fishing is not expected to have any long-term impacts on predator fish populations. Most predators are opportunistic in their feeding

habits. However, short-term impacts to individual fish could be experienced. Available information is insufficient to determine the extent of any short-term impacts to individual fish associated with the removal of herring for commercial purposes. Since king salmon use herring in nearshore staging areas and essentially stop feeding once they are in the bay, the effect of fisheries-related removals is minimized. However, the annual removal of roughly 15 percent of spawning biomass by commercial fishing may lead to increases in search effort, to reduced capture success, to changes in movement patterns, or cause a switch in prey for those fish predators that rely most heavily on herring as a prey. These potential short-term impacts to individual fish are expected to be less than significant at population levels.

**Mitigation** Mitigation in recognition of the importance of herring as a forage item is provided by setting conservative exploitation rates of no more than 20% of spawning biomass. Further mitigation, if necessary, can be achieved by selection of Alternative 1. No additional mitigation is proposed for impacts to fish populations because they are expected to be localized, short-term and less than significant.

#### 4.2.7 Scenic, Recreation, and Noise

There are a number of factors associated with commercial herring fishing that could create scenic, recreation, and noise impacts affecting the area's ambiance, background noise level, and individual point of view. Certainly, the impact that commercial herring fishing might have on ambiance would differ between a highly urbanized environment like San Francisco Bay and that of a more rural environment like Humboldt Bay. Noise levels associated with commercial herring fishing will also vary with fishing intensity, gear type used, distance, and background noise level. For example, the eggs-on-kelp fishery produces very little noise compared to other gear types used. There may be some low level noise associated with placing rafts and lines but once they are in place the noise level drops significantly. The scenic quality of herring fisheries will be viewed as aesthetically pleasing by some and not by others. That individual point of

view can also vary with circumstance.

Various combinations of these factors have led to complaints during past herring roe fishing seasons in San Francisco Bay. Most of the complaints were related to noise from late night or early morning fishing activity.

The concentrated activity associated with the commercial herring roe fishery in San Francisco Bay could preclude the use of an area by recreational user groups for short periods of time.

Short-term disturbances from the commercial herring roe fishery are expected. However, no significant long-term impacts to scenic quality, noise level, or recreational uses are expected.

**Mitigation:** The adverse impacts to scenic quality, noise level, and other water uses are expected to be localized, short-term, and less than significant. Short-term impacts have been mitigated by regulation prohibiting fishing within 300 ft of selected piers, recreation areas, and buoyed channel entrances within San Francisco Bay. Impacts to recreational water use is also mitigated by regulation prohibiting commercial herring fishing from noon Friday through sunset Sunday. Herring fishing is also prohibited within Belvedere Cove and unloading of herring is prohibited at night (10 p.m. to 6 a.m.) in response to complaints about fishing related noise at night.